Nov. 5, 1940. J. PÄTZOLD ET AL 2,220,269

ELECTRODE MEANS

Filed Nov. 28, 1934

Fig. 1

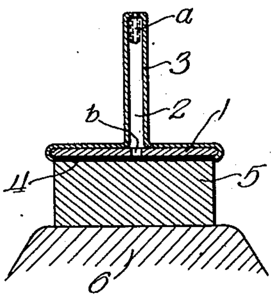


Fig. 2

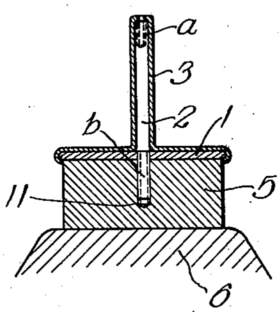


Fig. 3

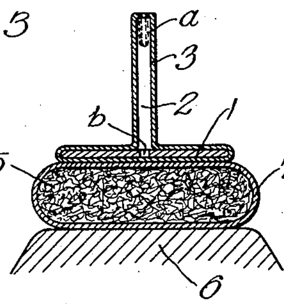


Fig. 4

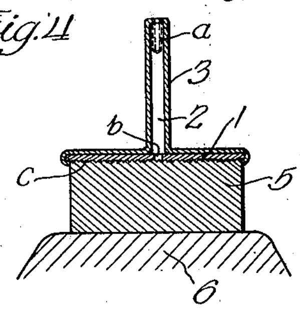


Fig. 5

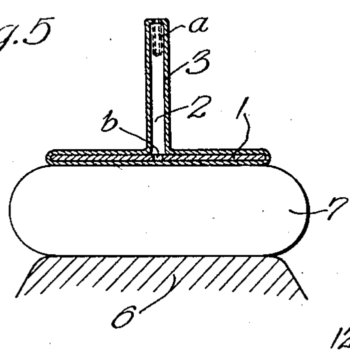


Fig. 6

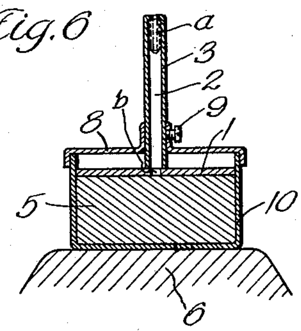
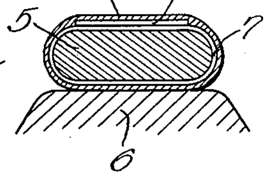


Fig. 7



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UNITED STATES PATENT OFFICE

2,220,269

ELECTRODE MEANS

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6 Claims. (Cl. 128—413)

Our invention relates to electrode means and is particularly concerned with electrode structures and arrangements for applying medical treatment with electric oscillations of very high frequency, on the order of 25 million cycles per second, for example.

Before describing the invention, we will furnish below a brief review of the art and of the underlying principles so that the invention may be readily understood and appreciated in all its objects and features.

Electrode arrangements for the purpose intimated above are distinguished from the so-called current or contact electrodes employed in diathermy by the provision of a layer of insulating material which is interposed between the metallic electrode and the subject to be treated. Early structures of this character employed for an insulator a layer of Celluloid or rubber which was just a few millimetres deep. Compared with the customary current or contact electrodes, the use of these structures presented the advantage of carrying out the high frequency treatment without producing burns which may be caused in the case of contact electrodes by poor contact between the electrode and the subject. However, the heating effect which could be obtained by the use of such electrode arrangements was limited substantially to the surface of the subject to be treated.

It was found subsequently that the heating of deeper strata, i. e., a more uniform heating of the subject, could be accomplished by using either the current or contact electrodes or the above indicated condenser electrodes, provided that the corresponding electrode was disposed at a distance from the subject so that contact thereof with the subject was avoided. Electrode arrangements wherein an air space was provided between the metallic electrode and the subject under treatment were therefore used in the past in conjunction with treatments in the condenser field. The air space was usually more or less completely enclosed by means of a layer of insulating material, such as glass, which was usually secured to the electrode and spaced therefrom.

The results obtained by the use of such electrode structures seemed to indicate that the penetration increases with increased distance of the metal electrode from the subject. However, an arbitrary increase of the distance from the subject or, rather to say, increase of the space between the subject and the electrode structure is not feasible for several reasons. In the first place, the total capacity of the treatment arrangement, which is composed of the capacity of the subject and the series capacities formed by the air space, decreases with increased air space and finally becomes so small that the treatment circuit cannot be tuned to the wave length of the oscillations employed. Another consideration resides in the output of the customary generators, that is to say, in the inability of the generator to supply the required high frequency energy to the subject under treatment beyond a given distance or air space between the electrode and the subject.

As a result of these difficulties, electrode arrangements were again employed for the treatment in the condenser field in conjunction with generators of average capacity, wherein a relatively thin layer of a few millimetres depth, consisting of insulating material, for example, of soft rubber, was provided between the metal electrode and the subject.

In order to increase the penetration in the case of electrodes of this character, the suggestion was made to provide, in addition to the relatively thin rubber layer an auxiliary layer of fibrous insulating material, such as felt or the like, i. e., to interpose between the metal electrode and the subject under treatment an insulating material containing air. The use of this material was proposed in order to approximate the conditions of the corresponding electrode structures to the conditions of those structures wherein only an air space is provided between the metal electrode and the subject to be treated and, accordingly, in order to obtain approximate results.

Our invention is based on the recognition of the concept that the assumptions previously applied in the construction of electrode arrangements for high frequency treatment in the condenser field were wrong. As explained previously, and disregarding the cases where a limited penetration and the provision of an air space are indicated for other reasons, prior investigators assumed that the provision of merely an air space between the metal electrode and the subject under treatment was most preferable. We believe this assumption to be in error.

Merely the provision of an air-filled space does not seem to be the deciding factor when it is desired to obtain favorable penetration; what seems to be deciding is a favorable depth of the space in conjunction with the property that it represents a small resistance for the electric oscillations used for the treatment. The medium connected between the subject and the metal electrode must be of such nature as not to affect the course of the lines of the electric field in a manner undesired to the treatment.

We have found that the penetration increases with increased distance of the metal electrode from the subject because the electric field exhibits a strong stray effect in close proximity to the electrodes while it is relatively uniform only in the central range between the electrodes. It follows that if the metal electrodes are arranged close to the surface of the subject under treatment, the density of the field will be considerably greater on the surface of the subject than in the deeper strata and, consequently, a stronger heating effect will be obtained on the surface. Conversely, if the distance between the electrodes and the subject is increased, the surface of the subject is progressively removed from the region where the stray effect is manifest and is increasingly brought under the influence of the relatively uniform region of the field which is present between the electrodes.

We have also discovered that sufficient high frequency energy for carrying out the medical treatment could frequently not be supplied to the subject with the use of the known electrode means wherein a considerable space substantially filled with air was provided in order to accomplish the expected improved penetration, because this space represents a prohibitive resistance for the high frequency oscillations. This will be apparent when it is considered that the space forms a very small capacity due to the small dielectric constant of the medium (air or felt) disposed therein.

As a further result of our investigation we found that the series connection composed of the air space and the subject, that is to say, the series relation of a medium with a very small dielectric constant (air=1) and a medium with a relatively high dielectric constant (biologic tissue=80) causes a marginal distortion of the field between the metal electrodes. The lines of force of the electric field are deflected upon transfer from one medium to the other according to the law governing the passage of lines of force through media of different dielectric constant, i. e., they bend from the normal upon transition from a medium with small dielectric constant to a medium with high dielectric constant. Accordingly, in the case of a series relation of air or air containing material and a biologic tissue, the change in the direction of the lines of the field is so great that they proceed immediately underneath and along the surface of the tissue, even incident to a relatively small deviation from the normal. This may be the reason for the extraordinary heating of perspiration layers forming upon the surface of the subject treated in the condenser field with electric oscillations of very high frequency.

As noted previously, our invention is concerned with novel and improved electrode arrangements and structures wherein the above mentioned drawbacks are avoided.

One object relates to the provision of a new electrode structure and arrangement wherein the thickness of the intermediate layer between the metal electrode and the object to which the electrical oscillations are applied is rather great, and preferably at least 10 mm. in depth, having a dielectric constant which is relatively high, that is, as high as possible under any given circumstances, and wherein the material used for this intermediate layer is of a non-fibrous and air-free structure.

Another object of the invention is concerned with the provision of an intermediate insulation layer in the new electrode structure, the dielectric constant of which is greater than 10.

The dielectric constant of the intermediate layer may be chosen so as to approximate that of the object to which the electrical oscillations are to be applied; for example, in the case of treating tissue it may be 80 or higher. Accordingly, it is another object of the invention to provide a new electrode structure, wherein the dielectric constant of the intermediate insulating layer is approximated to that of the object.

Other objects and features will appear as the following description progresses.

The layer may consist of a mixture of water and glycerine having a dielectric constant of 20 to 30; or it may consist of distilled water having a dielectric constant of about 80. Suitable substances may also be combined to form the insulating layer. Thus, mineral insulating material containing an addition of metal or metal combination may be used. The layer may also be made of high grade ceramic material containing oxide of a heavy metal. Substances such as known as "Condensa" consisting of steatite with an addition of titanium oxide (TiO_2) and other materials of this class known under the names "Condensa C" and "Kerafar" may also be used for the purpose of forming the layer. The dielectric constant of "Condensa" and "Condensa C" is 40 and 80, respectively, and that of "Kerafar" is about 100. Other known and suitable insulating substances made of mineral insulating materials, e. g., those known under the name "Mycalex" which consists of mica and lead borate, and other materials of this class known as "Calan," "Calit," Frequentit" may be used to advantage. Water, oil or liquid materials having kindred properties may also be employed.

Since from the point of view of treatment the insulating material interposed between the metal electrode and the subject must be deformable, it is desirable if solids are used to employ them in powdered form. The powder may conveniently be enclosed in an insulating casing for instance of rubber, the walls of which are thin in comparison with the depth of the powder layer.

When fluid insulators are used, it is desirable similarly to enclose these in a deformable insulating casing of rubber or the like.

It is also possible to employ relatively yieldable or plastic insulating materials such as wax and the like for use between the electrode and the subject, as previously intimated.

In view of the fact that some of the insulating materials suitable for our purposes may have a low dielectric constant, we propose to use such materials in connection with material of a higher dielectric constant. Thus, a mixture of wax and the previously noted materials "Mycalex" and "Condensa C" in powdered form may be used. Other combinations will suggest themselves in accordance with our teaching.

The dielectric constant of the liquid or substantially solid materials may also be modified, e. g., it may be raised according to our invention by adding thereto a powdered or pulverized metal.

The invention may be practised by disposing the insulating material with high dielectric constant only in a part of the space provided between the metal electrode and the subject to be treated. It is merely necessary in such a case that the part of the space containing a medium of small dielectric constant, for example air, is small when compared with the part of the space containing the medium of high dielectric constant.

Several embodiments of the invention are illustrated in diagrammatic form and partly in section in the accompanying drawing, Figs. 1 to 7, wherein like parts are designated by like reference numerals.

Referring now to the drawing, numeral **1** indicates the metal electrode. In the embodiments shown in Figs. 1 to 6, this electrode is joined with an electrode rod or handle **2** which may be provided at one end with a threaded extension *b* engaging the electrode. At the other end of the handle **2** is provided an internal thread *a*. Numeral **3** in Figs. 1, 2 and 4 designates an insulating coat or layer which covers the handle, the edge of the corresponding electrode and the outer side of the electrode **1**. In the embodiment shown in Figs. 3 and 5, the electrode **1** and the handle **2** are completely covered with the insulating coat, while in the embodiment according to Fig. 6 the insulating coat **3** is placed only on the electrode handle or rod **2**. Numeral **5** indicates the insulating material disposed between the subject **6** and the corresponding metal electrode **1**. The size of the electrode depends somewhat on the amount of power available, and it should not be so large that the requisite concentration cannot be obtained. Within the limits thus imposed, the size may be in proportion to the part to be treated, but in any event the area of the electrode should preferably be somewhat less than the area of the tissue to which it is presented in the treatment.

A substantially rigid insulating material **5** may be used in conjunction with the embodiment Fig. 1. One side of this material may be provided with a metallic coat which may be sprayed thereon, as is indicated in Fig. 1 by the reference numeral **4**. The layer of insulating material thus provided with a metallic film or coat may be soldered to the electrode. As shown in Fig. 2, the metal electrode **1** may also be joined with the relatively rigid insulating material **5** by a threaded connection by projecting the threaded portion *b* of the electrode handle through the metal electrode **1** and extending it into the threaded boring **11** in the insulating material **5**.

The structure illustrated in Fig. 3 includes the metal electrode **1** which is enclosed in the insulating envelope **3**. The flexible or yieldable bag or container **7** holds the insulating material **5** which in this case may be in the form of a powder.

The embodiment indicated in Fig. 4 shows an electrode arrangement wherein one side of the metal electrode **1** may be suitably roughened or etched or may be provided with suitable grooves *c*. The insulating layer **5** may consist in this case of a yieldable insulating material such as wax and the like. The roughened or grooved surface *c* facilitates the attachment of the yieldable layer of insulating material to the metal electrode **1**.

Fig. 5 shows an embodiment employing a yieldable envelope **7** containing a liquid insulating material such as water which is placed between the insulation covered electrode **1** and the subject **6**.

The structure illustrated in Fig. 6 comprises a relatively rigid container **10** holding the insulating material **5** as shown. The metal electrode **1** contacts the insulating material. The container **10** may be closed by means of a cover or lid **8** and the latter may be joined with the rod or handle **2** by means of a screw **9**. If compressible or yieldable insulating material **5** is used in conjunction with the structure shown in Fig. 6, the same may be compressed by shifting the handle **2** relative to the cover or lid **8** and setting the structure in any desired position by means of the screw **9**. This particular structure also permits adjustment of the space between the electrode and the subject under treatment when rigid insulating material is employed in the container **10**.

The arrangement according to Fig. 7 includes an external yieldable envelope **12** in which may be disposed the yieldable electrode **1** as indicated. The electrode handle is not shown in this figure; it will be clear, however, that the handle projects from the envelope **12**. This outer envelope contains the yieldable inner envelope **7** holding the yieldable insulating material. Numeral **6** designates the subject to be treated as in previously described figures.

Changes may be made within the scope and spirit of the claims which follow. We have defined in these claims what we believe to be new in the art, and it is expressly understood that we intend to use and employ any and all such structures and embodiments that may be covered by these claims, subject only to the showing of the prior art.

We claim:

1. In an electrode arrangement for applying to a body electric oscillations of very high frequency, the combination of a metal electrode and a layer of dielectric material for spacing said electrode away from the body to which said oscillations are applied, said layer having a dielectric constant aproximated to that of the body to which said oscillations are applied, which dielectric constant is higher than 10 but does not exceed the order of substantially 100 constituting a relatively small resistance for the electric field applied to said body.

2. In an electrode arrangement for applying to a body electric oscillations of very high frequency, the combination of a metal electrode and a layer of non-fibrous substantially air-free dielectric material having a thickness of at least 10 mm. for spacing said electrode away from the body to which said oscillations are applied, said layer having a dielectric constant which is higher than 10 but does not exceed the order of substantially 100 constituting a relatively small resistance for the electric field applied to said body.

3. In an electrode arrangement for applying to a body electric oscillations of very high frequency, the combination of a metal electrode and a layer consisting of liquid dielectric material for spacing said electrode away from the body to which said oscillations are applied, means for attaching said dielectric material to said metal electrode, said layer having a dielectric constant which is higher than 10 but does not exceed the order of substantially 100 constituting a relatively small resistance for the electric field applied to said body.

4. In an electrode arrangement for applying to a body electric oscillations of very high frequency, the combination of a metal electrode and a layer of dielectric material, consisting of a solid material in comminuted condition, for spacing said electrode away from the body to

which said oscillations are applied, means for attaching said dielectric material to said metal electrode, said layer having a dielectric constant which is higher than 10 but does not exceed the order of substantially 100 constituting a relatively small resistance for the electric field applied to said body.

5. In an electrode arrangement for applying to a body electric oscillations of very high frequency, the combination of a metal electrode and a layer of non-fibrous substantially air-free dielectric material for spacing said electrode away from the body to which said oscillations are applied, said layer having a thickness of at least 10 mm. and a relatively high dielectric constant substantially equivalent to that of the body to which the oscillations are applied which is preferably higher than 10 but does not exceed the order of substantially 100 constituting a relatively small resistance for the electric field applied to said body, said dielectric material serving to substantially equalize the effects of said oscillations in the surface and interior of such body whereby deleterious deflection of the lines of force on passing from said electrode arrangement to the body is substantially avoided and the ratio of internal penetration of said oscillations to surface effect thereof is increased.

6. In an electrode arrangement for applying to a body electric oscillations of very high frequency, the combination of a metal electrode and a layer of dielectric material, consisting of a mixture containing a solid material in comminuted condition and a fluid substance, for spacing said electrode away from the body to which said oscillations are applied, said layer having a dielectric constant which is higher than 10 but does not exceed the order of substantially 100 constituting a relatively small resistance for the electric field applied to said body.

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